INTERVENTIONAL CARDIOLOGY AND SURGERY

Octogenarians undergoing cardiac surgery outlive their peers: a case for early referral

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Objective: To examine short and long term outcomes of octogenarians having heart operations and to analyse the interaction between patient and treatment factors.

Methods: Multivariate analysis of prospectively collected data and a survival comparison with an age and sex matched national population. The outcomes were base in-hospital mortality, risk stratified by logistic EuroSCORE (European system for cardiac operative risk evaluation), and long term survival.

Results: 12 461 consecutive patients (706 over 80 years) operated on between 1996 and 2003 in a regional UK unit were studied. Octogenarians more often had impaired ventricular function, pulmonary hypertension, and valve operations. They also included a higher proportion of women, had a higher serum creatinine concentration, and had a trend towards more unstable angina. Younger patients had a higher prevalence of previous cardiac operation, previous myocardial infarction, and diabetes. The in-hospital mortality rate was 3.9% for all patients (EuroSCORE predicted 6.1%, $p < 0.001$) and 9.8% for octogenarians (predicted 14.1%, $p = 0.002$). Long bypass time and non-elective surgery increased the risk of death above EuroSCORE prediction in both groups. A greater proportion of octogenarians stayed in intensive care more than 24 hours (37% v 23%, $p < 0.001$). Long term survival was significantly better in the study patients than in a general population with the same age–sex distribution (survival rate at five years 82.1% v 55.9%, $p < 0.001$).

Conclusions: Cardiac surgery in a UK population of octogenarians produced excellent results. Elective referrals should be encouraged in all age groups.

Cardiac surgery in octogenarians is increasingly common and produces early results comparable with those obtained in younger age groups.¹ Elderly patients, on the other hand, have a higher procedure-related mortality and more postoperative complications, spend a longer time in hospital, and have higher acute care costs.^{1–3} But what is the cost of a more conservative strategy? Two recent reports examined what happens to elderly patients with ischaemic heart disease when they are assigned to revascularisation versus medical treatment.^{4,5} TIME (trial of invasive versus medical therapy in elderly patients with chronic symptomatic coronary artery disease) was a prospective trial of 305 patients with angina: it showed that at six months revascularisation, whether percutaneous or surgical, was associated with a better quality of life and fewer major cardiac events (19% v 49%) than in the medically treated group.⁴ The study, which randomly allocated treatment of patients at the time of presentation, concluded that the average 80 year old patient with symptoms not controlled by medication should benefit from angiography with a view to revascularisation. The APPROACH (Alberta provincial project for outcome assessment in coronary heart disease) study, based on a cardiac catheterisation database from Canada, analysed the absolute risk reduction in late mortality resulting from coronary surgery and percutaneous intervention compared with medical treatment. Paradoxically, the greatest benefit was achieved in patients ≥ 80 years of age.⁵ Although other studies have examined survival and quality of life,^{2,6,7} little is known about the extent to which a cardiac operation influences life expectancy in the elderly.

Such evidence is leading to more cardiac surgical referrals in the elderly. In the UK, results of cardiac surgery continue to be under intense medical and public scrutiny,

with in-hospital death an easily verifiable outcome.⁸ Recommendations have been made to use risk stratification based on low risk cases for assessing surgical performance.⁹ Compared with crude mortality rates this is scientifically sound and may avoid risk averse surgical behaviour. However, among patients undergoing isolated coronary surgery, half of those who die are at high risk, defined by Bridgewater and colleagues as having an estimated risk of death of greater than 5% and representing 15% of their patients.⁹ Octogenarians belong to a higher risk group and special tools are needed to evaluate their outcomes. Various risk scores based on patient characteristics are in use in the UK, among them being Parsonnet, EuroSCORE (European system for cardiac operative risk evaluation) additive, and EuroSCORE logistic.^{10–12} In Parsonnet and EuroSCORE additive each risk factor is given a weight or a number of points. When added, they provide an estimate of the percentage predicted mortality for a patient undergoing a particular procedure. Their main drawback is poor prediction in high risk subsets. EuroSCORE logistic takes advantage of proliferating information technology and uses the full logistic equation of EuroSCORE better to predict mortality, particularly for patients with an estimated risk of death in excess of 7%.¹² Regardless of the system used, octogenarians invariably score high in terms of estimated risk of death on account of age and co-morbidity. This in turn may lead to difficulties in counselling and hesitation in offering and accepting surgery.

Abbreviations: APPROACH, Alberta provincial project for outcome assessment in coronary heart disease; CI, confidence interval; EuroSCORE, European system for cardiac operative risk evaluation; TIME, trial of invasive versus medical therapy in elderly patients with chronic symptomatic coronary artery disease

This situation calls for an informed debate about referrals, outcomes, and resource utilisation. Papworth Hospital has developed a special interest in data collection and risk modelling. Furthermore, in the recent report of the Society of Cardiothoracic Surgeons of Great Britain and Ireland Papworth is the unit operating on the oldest patients, with a mean age significantly higher than both the national average and the mean age at the centre with the next oldest patients.¹³ By using a prospective database we set out to determine trends and outcomes of operations for octogenarians. Recognising that the estimated risk of death comes primarily from patient factors we examined their interaction with two modifiable system factors: clinical priority (elective versus urgent versus emergency) and length of cardiopulmonary bypass. Our main objective, however, was to study long term survival compared with published survival rates from the national cohort matched by age and sex.

METHODS

Patients are referred to surgeons after being assessed and investigated by a cardiologist either at the request of the patient's general practitioner or having presented with an acute cardiac event. The overwhelming majority (> 98%) of patients referred to surgeons are offered an operation and accept it. Thus, most patients are selected before they see the surgeon.

Data were collected on all consecutive patients operated on at Papworth Hospital between April 1996 (when this unit started EuroSCORE prospective risk stratification) and October 2003. Consultant anaesthetists and audit coordinators regularly validate the database, which has an average accuracy of 98.9% when checked against case notes. An urgent operation was defined as a procedure taking place during the same hospitalisation as the referral and performed by the first available surgeon in an in-house urgent operating slot. An emergency operation, also prospectively defined in the database, was a procedure performed immediately after referral and before the start of the next working day. Patients' characteristics were compared by the χ^2 and Fisher's tests. The logistic EuroSCORE was used to stratify patients, since it is known to be the most accurate predictor of death in high risk cases.¹²

The primary short term outcome was death at the base hospital (Papworth). Octogenarians' necropsy reports were examined. Cardiac death was defined as resulting from pump failure, recent myocardial infarction, or an arrhythmic event. Multivariate logistic regression models were constructed by using death in our hospital as the outcome and including the logistic EuroSCORE. Other clinical variables entered were surgical priority (elective, urgent, emergency) and length of cardiopulmonary bypass time. The models were fitted for all patients and separately for octogenarians to compare the magnitude of effects. To assess whether the influence of clinical factors on in-hospital mortality was greater for octogenarians age-priority and age-bypass time interactions were included in the model.

Long term survival for over 80s was determined through the NHS Strategic Tracing Service by using 15 November 2003 as reference date, 30 days after the last operation in the series. We compared survival in our cohort with UK population survival rates expressed as interim life tables obtained from the Government Actuary's Department. These life tables were used to estimate expected survival for a UK population with the same age-sex distribution as our cohort. Standardised mortality ratios were calculated to compare observed with expected survival.

Length of intensive therapy unit stay was measured until discharge, whether the patient was dead or alive. The

Table 1 Patient characteristics

	Under 80 years (n = 11755)	Over 80 years (n = 706)	p Value*
Age (years)	64.74 (10.14)	82.82 (2.35)	NA
Women	2881 (24.5%)	288 (40.9%)	<0.001
Operations			
CABG	7898 (67.3%)	285 (40.4%)	<0.001
Valve surgery	1850 (15.8%)	192 (27.2%)	
CABG + valve	951 (8.1%)	206 (29.2%)	
Thoracic aorta surgery	455 (3.9%)	13 (1.8%)	
Major cardiac surgery	208 (1.8%)	4 (0.6%)	
CABG + major cardiac	359 (3.1%)	5 (0.7%)	
Other major surgery	14 (0.1%)	0 (0%)	
Previous cardiac operation	774 (6.6%)	24 (3.4%)	0.001
Previous myocardial infarction	4520 (38.5%)	219 (31.0%)	<0.001
Priority			
Urgent	1613 (13.7%)	149 (21.1%)	<0.001
Emergency	786 (6.7%)	49 (6.9%)	
Diabetes	1540 (13.1%)	64 (9.1%)	0.002
Systolic function			
Moderate	4031 (34.3%)	283 (40.1%)	0.004
Poor	1430 (12.2%)	88 (12.5%)	
Hypertension	5627 (47.9%)	316 (44.8%)	0.108
Creatinine >200 μ mol/l	188 (1.6%)	23 (3.3%)	0.001
Chronic pulmonary disease	515 (4.4%)	40 (5.7%)	0.108
Extracardiac arteriopathy	796 (6.8%)	55 (7.8%)	0.298
Neurological dysfunction	107 (0.9%)	6 (0.8%)	0.869
Active endocarditis	96 (0.8%)	4 (0.6%)	0.469
Critical preoperative state	510 (4.3%)	32 (4.5%)	0.806
Unstable angina	653 (5.6%)	50 (7.1%)	0.088
Pulmonary hypertension†	181 (1.5%)	22 (3.1%)	0.001
Postinfarct septal rupture‡	80 (0.7%)	5 (0.7%)	0.765

Data are mean (SD) or number (%).

* χ^2 test; †systolic pulmonary artery pressure >60 mm Hg; ‡Fisher's exact test.

CABG, coronary artery bypass grafting; NA, not applicable.

Table 2 In-hospital mortality as observed in the study group in comparison with the logistic EuroSCORE prediction

	Observed (%) (95% CI)	Expected (%) (EuroSCORE logistic)	p Value
All patients (n = 12 461)	3.9 (3.6 to 4.3)	6.1	<0.001
Over 80 (n = 706)	9.8 (7.8 to 12.2)	14.1	0.002
Over 80, CABG only	8.8 (5.6 to 12.9)	11.25	p = 0.21
Over 80, valve only	9.4 (5.6 to 14.8)	15.05	p = 0.04
Over 80, CABG + valve	9.7 (5.9 to 15.0)	15.31	p = 0.03

CI, confidence interval.

Mann-Whitney test was used to compare length of stay for the two groups.

RESULTS

In the study period 12 461 consecutive patients had cardiac surgery and of these 706 were over 80 years of age at the time of the operation. The proportion of octogenarians more than doubled between 1996 and 2003, from 4.1% to 9.8% ($p < 0.001$). Octogenarians more often had impaired ventricular function, pulmonary hypertension, and valve operations. They also included a higher proportion of women, had a higher serum creatinine, and had a trend towards more frequent unstable angina (table 1).

Younger patients had a higher prevalence of previous cardiac operation, previous myocardial infarction, and diabetes. Despite this risk profile our actual mortality rates are significantly better than predicted, for all patients (3.9%, 95% confidence interval (CI) 3.6 to 4.3) as well as for octogenarians only (9.8%, 95% CI 7.8 to 12.2) (table 2).

Table 3 Multivariate logistic regression on risk of in-hospital death

	All patients (n = 12461)		Patients over 80 years (n = 706)	
	OR (95% CI)	p Value	OR (95% CI)	p Value
EuroSCORE logistic	1.038 (1.030 to 1.045)	<0.001	1.031 (1.013 to 1.050)	0.001
Bypass time (min)*	1.014 (1.012 to 1.016)	<0.001	1.011 (1.004 to 1.019)	0.004
Elective surgery†	1	<0.001	1	0.004
Urgent surgery	1.8 (1.4 to 2.4)		2.3 (1.2 to 4.1)	
Emergency surgery	3.0 (2.2 to 4.0)		3.3 (1.4 to 7.9)	

Results are expressed as odds ratio (ORs) for in-hospital death.

*In the case of continuous variables the OR represents an increase in risk of death per increase in unit of the variable, relative to the mean (for example, for the corresponding exponential transformation, the ORs for an increase of five points in logistic EuroSCORE (relative to the mean) is 1.165 (95% CI 1.067 to 1.276) for the octogenarians; similarly, in over 80s an increase of 10 minutes' bypass time gives an OR of 1.116 (95% CI 1.041 to 1.207)).

†Reference category.

Emergency operations accounted for 7% of all procedures among both octogenarians and non-octogenarians (49 v 823). However, over 80s had significantly more urgent operations: 21% v 14%, (147 v 1646, $p < 0.001$).

Bypass time and priority were independent predictors of death, above the risk score estimates, in all the models constructed (table 3). These factors were equally important for both octogenarians and non-octogenarians and there were no significant interactions. All models were refitted by using Parsonnet and the additive EuroSCORE with no notable change in results and conclusions (results not shown).

Median length of stay in the intensive therapy unit, although comparable in absolute terms, was longer for octogenarians (21.9 hours, interquartile range 18.3–38.9 v 21.2 hours, interquartile range 18.2–23.7, $p < 0.001$) due to a higher proportion of long stays. The proportion of patients staying in intensive care for more than 24 hours was 37.1% (95% CI 33.5 to 40.7) for octogenarians compared with 23.0% (95% CI 22.2% to 23.8%) for younger patients ($p < 0.001$) (262 v 2704). Postmortem examinations were performed in 51 octogenarians who died in hospital (74% of in-hospital deaths). In these 51 patients the median interval between operation and death was four days. The causes of death were cardiac in 36 patients (70%), followed by infection (12%), gastrointestinal (10%), neurological (4%), vascular (2%), and technical (2%). Cardiac causes of death were equally distributed between 26 patients who had elective surgery and 25 who had non-elective surgery in this group.

Long term survival was studied in the octogenarian group. Follow up time ranged from one month to 7.6 years. Long term prognosis was better in our cohort than in a general population matched for age and sex. The standardised

mortality ratio (observed deaths compared with expected in the general population) was 45.6% (95% CI 37.2 to 54.0, $p < 0.001$). Actuarial survival was better than the general population estimate in every year of follow up (fig 1), except in the first postoperative year, when it was lower (83.7% v 90.9%). Five year survival was 82.1% (95% CI 79.0% to 85.1%) compared with 55.9% in the general population. The numbers at risk among the operated octogenarians were 569 and 256 at one and five years, respectively. Women and men were also analysed separately with similar results (not shown here).

DISCUSSION

This is the largest UK single centre experience and the largest risk stratified, comparative study in the world examining long term outcomes of cardiac surgery in the elderly. It confirms that selected octogenarians can undergo cardiac surgery with good results. Over seven years our unit has witnessed more than a doubling of the proportion of patients over 80 undergoing surgery. The figure reflects the surgeons' increasing willingness to take on older patients and this pattern is probably seen elsewhere in the UK. Patient characteristics are in keeping with aging (table 1). It should be noted that octogenarians are referred and operated on despite important co-morbidity. In-hospital mortality in our patients was significantly better than predicted by logistic EuroSCORE (table 2) and should serve to encourage surgery in the elderly in units where similar results can be achieved.

The risk scores used in cardiac surgery are mostly a collection of non-modifiable patient and procedure risk factors. We reported elsewhere how preoperative prediction is enhanced when a few intraoperative events are added to the model.¹⁴ The current study also aimed at raising awareness about modifiable factors, which in turn may lead to better outcomes in high risk subgroups. Length of cardiopulmonary bypass is such a factor. Extracorporeal circulation is non-physiological. The surgeon has to make a judgement in the individual case about achieving a technically good result in the shortest possible time. However, a long bypass time may also correlate with several patient factors, some unquantified: type of procedure, size and quality of conduits and target vessels, and unexpected operative difficulties. A variable of wider interest, and certainly more modifiable, is clinical priority. Central to prioritisation is the patient's condition at the time of referral. Risk models cater for priority in a limited and variable way. The definition of emergency may vary, for example, between North America and Britain.¹⁵ In our database we have added the urgent category, which better reflects the situation encountered in British hospitals. A patient with unstable angina temporarily controlled by medication is generally operated on urgently rather than emergently. In this series of octogenarians, 28% underwent non-elective surgery, as

Figure 1 Long term survival of octogenarians in the series compared with an age matched population. $p < 0.001$, log rank test.

opposed to only 21% in below 80s, and was associated with a much higher risk of death (table 3). In the light of studies favouring an aggressive strategy for managing angina in the elderly,⁴⁻⁵ we too feel that these patients are best investigated early and referred for operation electively to achieve the best possible outcome.

In terms of necropsies, three of five patients with fatal gastrointestinal complications (6% of necropsies) had low flow gut ischaemia. If we add the other two to technical and infectious complications it follows that only 18% of deaths were not directly related to a cardiovascular cause. By focusing on cardiovascular management in all the perioperative stages results may be improved further.

The most important finding is that octogenarians undergoing cardiac surgery have dramatically better long term survival than an age and sex matched UK population, with a more than 50% reduction in standardised mortality. Such a comparison has not been previously undertaken. This outcome is observed even though cardiac disease remains the major cause of long term mortality after heart operations.¹⁶ Of course, the incidence of cardiac-related deaths in the general population of octogenarians is difficult to determine and may be higher still. There are several potential explanations for the improved long term survival. Firstly and most important, selection bias operates in our study. It is highly likely that referring general practitioners and cardiologists exercised clinical selection judiciously, particularly for elective surgery, and the cohort referred for elective heart operations may be more robust and with less co-morbidity than a random sample of octogenarians. Selection bias, however, operates in two opposing ways. The very elderly patient with multiple co-morbidity and very poor functional status is unlikely to be referred for elective surgery. Our study shows, however, that octogenarians have urgent and emergency cardiac surgery more often than younger patients. In a separate study of urgent and emergency aortic valve replacement, we found that most patients were known to have symptomatic and significant aortic valve disease for some time before decompensation and that referral was reluctant because of perceived increased risk related to age and co-morbidity (Billing and Nashef, manuscript in preparation). Cardiac surgeons are familiar with patients who have an operative indication but are deemed "too old" at the time of assessment and follow up. However, when the disease decompensates, age and co-morbidity are somehow no longer seen to be issues and the patient, previously deemed too ill for elective surgery, is referred for emergency surgery. Table 3 shows that non-elective surgery, more frequent in the elderly, is a strong independent predictor of death. We therefore strongly encourage elective referrals. Secondly, surgical patients may have a survival advantage resulting from secondary prevention of cardiovascular events. Our five year survival rates are superior to actuarial figures of 63% reported by others, which may be related to different patient demographics.⁶⁻¹⁶ We have not studied quality of life

outcomes but other investigators recorded that 87–99% of elderly patients were satisfied with their operation and improvement in quality of life.⁶⁻⁷ We believe this makes a compelling case for offering informed choice about surgery to these patients.

Conclusions

In summary, octogenarians can undergo cardiac surgery with acceptable mortality and morbidity and may have improved life expectancy. Non-elective surgery increases the risk of in-hospital death in all age groups. The relatively high rate of non-elective operations among the elderly suggests that many of these patients are treated medically and may be referred for surgery only at times of crisis.

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There are no competing interests.

REFERENCES

- 1 Alexander KP, Anstrom KJ, Muhlbaier LH, et al. Outcomes of cardiac surgery in patients age ≥ 80 years: results from the national cardiovascular network. *J Am Coll Cardiol* 2000;**35**:731–8.
- 2 Engoren M, Arslanian-Engoren C, Steckel D, et al. Cost, outcome, and functional status in octogenarians and septuagenarians after cardiac surgery. *Chest* 2002;**122**:1309–15.
- 3 Barnett SD, Halpin LS, Speir AM, et al. Postoperative complications among octogenarians after cardiovascular surgery. *Ann Thorac Surg* 2003;**76**:726–31.
- 4 Anon. Trial of invasive versus medical therapy in elderly patients with chronic symptomatic coronary-artery disease (TIME): a randomised trial. *Lancet* 2001;**358**:951–7.
- 5 Graham MM, Ghali WA, Faris PD, et al. Survival after coronary revascularisation in the elderly. *Circulation* 2002;**105**:2378–84.
- 6 Kolh P, Kerzemann A, Lahaye L, et al. Cardiac surgery in octogenarians: peri-operative outcomes and long-term results. *Eur Heart J* 2001;**22**:1159–61.
- 7 Mittermair RP, Muller LC. Quality of life after cardiac surgery in the elderly. *J Cardiovasc Surg (Torino)* 2002;**43**:43–7.
- 8 Keogh B, Kinsman R. *National adult cardiac surgical database report 2000–2001*. London: Society of Cardiothoracic Surgeons of Great Britain and Ireland, 2002.
- 9 Bridgewater B, Grayson AD, Jackson M, et al. Surgeon specific mortality in adult cardiac surgery: comparison between crude and risk stratified data. *BMJ* 2003;**327**:13–7.
- 10 Parsonnet V, Dean D, Bernstein AD. A method of uniform stratification of risk for evaluating the results of surgery in acquired adult heart disease. *Circulation* 1989;**70**(suppl 1):3–12.
- 11 Nashef SAM, Roques F, Michel P, et al. European system for cardiac operative risk evaluation (EuroSCORE). *Eur J Cardiothorac Surg* 1999;**16**:9–13.
- 12 Michel P, Roques F, Nashef SAM. Logistic or additive EuroSCORE for high-risk patients? *Eur J Cardiothorac Surg* 2003;**23**:684–7.
- 13 Keogh BE, Kinsman R. *Fifth national adult cardiac surgical database report 2003*, The Society of Cardiothoracic Surgeons of Great Britain and Ireland. Henley-on-Thames: Dendrite Clinical Systems, 2004.
- 14 Stoica SC, Sharples LD, Ahmed I, et al. Preoperative risk and intraoperative events in cardiac surgery. *Eur J Cardiothorac Surg* 2002;**21**:41–6.
- 15 Bridgewater B, Neve H, Moat N, et al. Predicting operative risk for coronary artery surgery in the United Kingdom: a comparison of various risk prediction algorithms. *Heart* 1998;**79**:350–5.
- 16 Sjogren J, Thulin U. Cause of late death after cardiac surgery in the very elderly: a single institution experience. *Scand Cardiovasc J* 2002;**36**:123–8.